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VISION SYSTEM FOR HUMAN BODY INFRARED THERMOGRAPHY

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Abstract: *A new method in medicine for detecting and investigating the illness like breast cancer is the Infrared Thermographic Imaging. A temperature map of human body is taken by an infrared thermal camera. The exact localization of specific areas from 2-dimensions thermal map is difficult and implies an invasive intervention of medicine doctors. In order to automatize this process a special scanner for acquire a 4-dimensions map is proposed and consist of: the 3-D scanner and the temperature sensor. In present paper an example of acquisitions the 4-D temperature map in the breast region is presented.*

Key words: *infrared thermographic imaging, temperature map, medicine, breast investigation*

1. INTRODUCTION

Breast cancer represents one of the most frequent diseases among women, being responsible for as much as 15% of deaths caused by cancer. Today, the most widely known and accessible method to detect the breast cancer is the mammography, but this procedure has two significant disadvantages: it only confirms the disease when it already is in a quite advanced state, and gives a rather large number of false positives, which alarms women and requires additional analyses. Other alternative methods of confirming the illness like mammary ecography, RMN, MRI**,** X-rays analysis of hair fibers, are different approaches from the classic method made in the hope of obtaining safer, more exact and less traumatic results (Nyirjesy et al., 1986).

Thermography is a painless, non invasive, state of the art clinical test without any exposure to radiation, no contact with the body and is used as part of an early detection program which gives women of all ages the opportunity to increase their chances of detecting breast disease at an early stage. It is particularly useful for women under 50 where mammography is less effective (Belliveau et al., 1998; Keyserlingk et al., 2000).

Present study is developing a methodology and is putting into operation a medical procedure which offers incipient form detection of this kind of malign tumor through automation of the thermography process. We thus hope to offer a safer, rigorous and non-traumatic method of prevention and early detection of this disease through determining the size and location of the nodule inside the breast (Tiu et. al., 2008).

The method is based on determining the spot with the higher temperature – the nodule – temperature which reflects on the outside surface of the breast by the radiation law on a surface (Hantila et al., 2008). By reversing the method (which means knowing the distribution of heat on a surface), through software means, the radiant source – the nodule – is detected. The project consists of the detection of the temperature distribution on a surface which leads to the elaboration of a 4-D model (*X*, *Y*, *Z*, *T*) of the patient's body, and then to calculate the position and size of the nodule inside the breast if is the case. The compact dimension of the whole technological ensemble involved represents an important advantage of the project, one which will be capitalized in a future development through developing of mobile diagnostic stations, which will be easily mountable in ambulances.

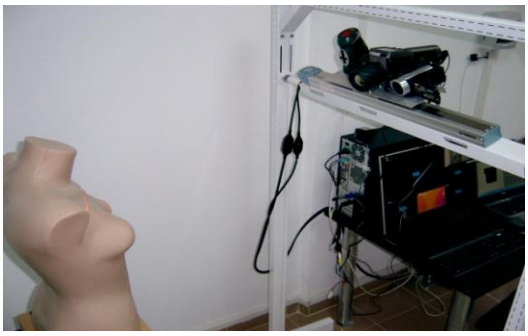

Fig. 1. The automated thermography system

2. PROPOSED METHOD

A Thermography is based on the principle that metabolic activity and vascular circulation in both pre-cancerous tissue and the area surrounding a developing breast cancer is almost always higher than in normal breast tissue (Gautherie, 1983). Cancerous tumors require an ever-increasing supply of nutrients and therefore increase circulation to their cells by holding open existing blood vessels, opening dormant vessels, and creating new ones (neoangiogenesis). This process frequently results in an increase in regional surface temperatures of the breast. Digital Infrared Imaging uses extremely sensitive medical infrared cameras and sophisticated computers to detect, analyze, and produce high-resolution diagnostic images of these temperature variations. Because of DII's sensitivity, these temperature variations may be among the earliest signs of breast cancer and/or a pre-cancerous state of the breast (www.breastthermography.com, 2009).

The exact localization of specific areas from 2-dimensions thermal map is difficult and implies the intervention of medicine doctors or the using of other investigation methods presented above. In order to automatize this process a special scanner (Fig. 1) for acquire a 4-dimensions map is used and consist of: the 3-D scanner and the temperature sensor.

The purpose of the hardware architecture of the system adopted for this application is the development of a mobile analysis equipment. For this matter, the system acquisition data is performed by an automated system which is composed of a mobile ensemble mounted on a rigid frame, and the system processing data is performed by a modern computer.

The actual acquisition of data is achieved by the mobile ensemble, through its movement on a single 600mm horizontal axis fixed on the rigid frame, thus covering the whole width of the patient's body. The patient will stand at a preset distance from the rigid frame and will remain stationary through the whole data acquisition. The data processing is achieved by a real time computing system which with the help of National Instruments LabView 8.6 software offers the 4-D model as final objective.

3. METHODOLOGY

The principle used in obtaining the 3-D model is the triangulation scanning. A laser diode emits a laser beam

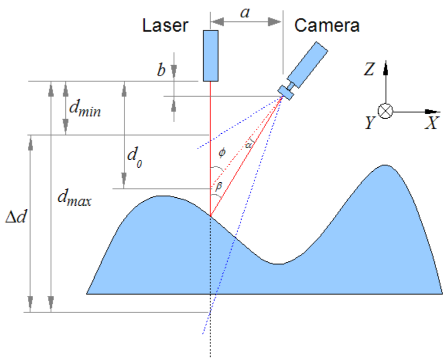

Fig. 2. Triangulation process scheme

focalized as a triangle. When the laser beam will illuminate an object with an irregular surface, this will describe a curved line which will be detectable by the video camera (Fig. 2). The 3-D coordinates of each pixel on the video camera curve, relative to the coordonate system attached to the scanning device, can be calculated through the triangulation process.

In order to extract the 3-D coordonates from the 2-D coordinates of the image the next algorith is used. A laser beam is reflected on the surface of an object and is detected by the CCD sensor as a bright spot p having p_x and p_y coordinates. The $oxyz$ system attached to the CCD camera sensor has its origin o in the centre of its sensitive matrix. The determination of P_X, P_Y, and P_Z coordinates of the real reflexion point is the aim.
The following notations were used (Fig. 2):

- f : focal length of the camera ;
- a: the distance between the laser light plane and the focal point of the camera ;
- b : distance between the XOY plane and the focal point of the camera ;
- ϕ : the angle between the camera axis and the laser diode axis OZ ;
- β : the angle between the laser light plane and the plane determined by the OY axis and the reflected beam that reaches the photosensible element of the camera ;
- α: the angle betweem the reflected beam and the oxy plane
- γ : angle α maximmum value ;
- d_{min}: the minimum distance measured by the device ;
- d_{max}: the maximum distance measured by the device ;
- d_0**:** the distance measured by the device when the reflected beam touches the ox axis of the sensor.

The laser diode emits in the negative direction of the Z axis, and the laser light is focused in the YOZ plane. Therefore, every point measured by the laser device will have the X coordonate equal to 0, and the Y and Z coordinates will be determined by the position of the light pixel on the CCD matrix with relations:

$$P_Y = \frac{a}{f \sin\left(\phi - arctg\frac{p_y}{f}\right)} p_x$$
$$P_Z = \frac{-a}{tg\left(\phi - arctg\frac{p_y}{f}\right)} - b \qquad (1)$$

4. RESULTS

The curvature of the laser beam from the video feed describes the horizontal dimension of the patient.

For a more efficient localization the using of some helping markers are considered, represented in this case by the circular material of black colour around the breast (Fig. 3).

Using advanced geometrical forms matching algorithms in the video image analysis, a constant size circle can be identified in each frame which will represent the “workspace”. Multiple filters are consecutively applied on each image in order to obtain a more exact position of the laser beam in each moment,

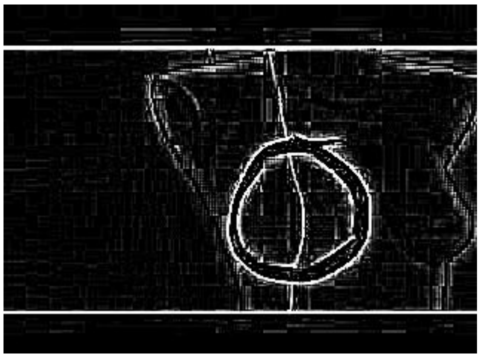

Fig. 3. Processed video image with filters and pattern matching

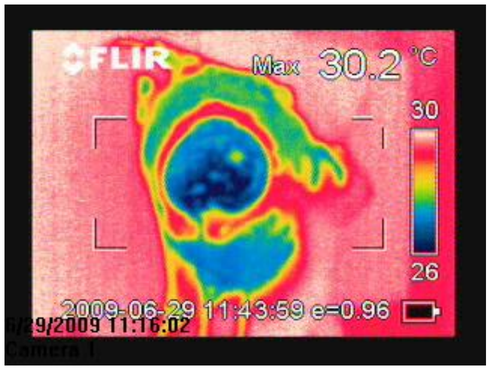

Fig. 4. Unprocessed image received from thermal camera

as can be seen in the picture (Fig. 3).

The 3-D characteristics of the body can be maped using mathematical formulas with the frame number, and video image laser beam pixel height and width as parameters.

The thermal image (Fig. 4) is taken when the thermal camera is situated right perpendicular to the patient while the ensemble is moving on the horizontal Cartesian axis. The use of the circular mark is beneficial for two reasons in this case. Firstly, the material is colder than the human body, and the resulting temperature difference means easier analysis and interpretation of the image. Secondly, the dimension of the circular mark is constant, and it is easy to calculate a relation between the dimension of the two types of images – video and thermal – for an efficient and exact interpolation of data.

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